Assistive Technology:- An Alternative for Locomotion Disability and Resultant Social Participation

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Abstract— **Having effective mobility is crucial to carry out daily activities and participate in social roles. This paper presents a robot that can detect hand gestures and provide assistance to people with mobility impairments, including the elderly and those with disabilities. The proposed technology utilizes image processing with the Raspberry Pi Arm – 11 board (700 MHz) to control the dc motors, which are connected to motor driver circuits (L298). The robot's actions are based on the data received from a webcam interfaced by USB ports. The processors used are compatible with Linux and GUI operating systems, making the technology both high-performance and economical.**

Keywords— *Social Applications, Wheezy Raspbian, Raspberry Pi, Hand Gesture, Python, Image Processing*

I. Introduction

Assistive technologies are designed to support individuals with disabilities who face challenges with their daily routine activities and may experience social isolation. These technologies help disabled individuals become more independent, while also making it easier for caretakers to support them, thus increasing productivity. Many modern devices have been developed, including mobility aids such as cranes and wheelchairs, to name a few. According to the 2011 census, India has a total of 27 million people with disabilities, with around 5.4 million having mobility impairments. Due to economic inequalities, only a small fraction of these individuals have access to wheelchairs. In light of these statistics, there is a need for affordable and easy-to-use wheelchairs, both for home use and institutional care of the elderly and disabled.

II. Conceptual Framework

The primary purpose of a wheelchair is to provide an alternative for those with mobility impairments, enabling them to carry out daily activities and participate in social roles. A study by Barker et al. found that using a wheelchair significantly increased the autonomy and freedom of disabled individuals in their social roles. Mobility is essential for activities such as health, personal hygiene, education, work, play, and social behaviour. Therefore, utilizing technology-enabled devices could help individuals with mobility impairments perform a wide range of activities and increase their social participation. This research paper aims to develop a cost-effective and efficient hand gesture recognition technology using image processing for wheelchairs, which would assist individuals with mobility impairments.

Current technology in this field typically relies on either voice control or remote control, which can be expensive and may not be easy to use. While some techniques use eye movements to control wheelchairs, they require carrying a laptop or notebook to operate, which compromises the technology's compactness. Therefore, in order to overcome the limitations of existing technologies, the researchers have developed a gesture recognition system.

III. Description of the Technology

To begin the project, the researchers first installed the Linux operating system onto the Raspberry Pi board using a micro-SD card. They then developed the necessary code using Python Programming Language and OpenCV libraries and interfaced the motor driver configuration alongside the webcam to the board. The images captured from the webcam were processed, and a pulse was transmitted towards the L298 motor driver configuration to permit or to prohibit the operation of the all the DC motor, with logic 1 indicating rotation

and logic 0 indicating holding. The researchers aimed to achieve three deliverables:

1. Capturing images and redirecting them to the Raspberry Pi.
2. Developing suitable code to process the captured images.
3. Enabling the DC motors based on thee processed image data.

The hardware and the software requirements for the same being:

Hardware Requirements	Software components
Raspberry Pi	Ubuntu 12.04
L298 Motor Driver Circuit	Python
Webcam	OpenCV
DC Motor	Geany
	Xming
	Putty

Table 1: List of hardwares & softwares

IV. HARDWARE COMPONENTS

A. Raspberry Pi

With its affordability, versatility, and small form factor, the Raspberry Pi was designed to assist people in learning programming and create DIY projects. Created by the Raspberry Pi Foundation, a UK charity dedicated to promoting computer science education, it was brought into being.

The physical Raspberry Pi hardware component is about the size of a credit card and comes with a range of input/output ports, including HDMI, USB, and Ethernet. It runs on a range of Linux-based operating systems, such as Raspbian and Ubuntu, and a broad spectrum of tasks can be performed with it, such as running basic applications, web browsing, hardware device control, and server operation.

Its GPIO (General Purpose Input Output) pins are among the Raspberry Pi's main features, which allow users to connect and control a range of electronic components, such as sensors, motors, and LEDs. It has enormous applications, making it the best suited board for the purpose of our project.

B. L298 Motor Driver

The L298 motor driver is an integrated circuit that is used to control the speed and direction of DC motors. It consists of two H-bridge circuits that can drive two DC motors, or one stepper motor. The L298 motor driver is popularly used in robotics, automotive and industrial applications.

The L298 motor driver has four input pins that can control the speed and direction of the motor. By providing PWM (Pulse Width Modulation) Signals to these pins, the user can adjust the speed of the motor.

The direction of the motor can be controlled by setting the inputs to high or low.

The major advantage of using L298 motor driver is its ability to handle high current loads. It can handle currents up to 2 amps per channel, making it suitable for driving large motors. The L298 motor driver can also be easily integrated with microcontrollers, such as Arduino, Raspberry Pi, and other popular development boards, making it easy to control motors with digital signals.

C. Webcam

A webcam, short for web camera, is a digital camera that is designed to capture video or still images and transmit them over the internet. It is commonly used for video conferencing, online chatting , live streaming, and remote monitoring.

Webcams can capture images in various resolutions ranging from standard definition to high definition, depending on the model and specifications of the device. Some webcam may also come equipped with features such as autofocus, zoom, and low-light correction to enhance the quality of the captured images.

Figure.1 Webcam

Webcam Lens	3 Glass Lens
Wire	1.3M Long
Interface	USB 2.0
Driver	Plug and Play Free Driver
Resolution	640*480=300K Mega
Focus Range	3cm Infinity
Microphone	With Mic
Video Recording	Yes
Night Vision	Yes
View Angle	360°
System Support	≥XP2, Win 7/8/Vista, Mac
Warranty	One-year

Table:2 Specification sheet of webcam

These days webcam have greatly evolved, by providing better resolution, and they are commercially used for communicating and collaborating with others from anywhere in the world. Along with that, they are also widely being used for security and surveillance purposes, enabling users to monitor their homes, offices, or other locations remotely.

D. DC (Direct-Current) Motor

Parameters	Units	Value
Nominal voltage	V	24
No-load speed	rpm	4000
No-load current	A	0.7
Rated speed	Rpm	3270
Maximum power	W	84
Maximum efficiency	%	67
Stall torque	Nm	0.80
Starting current	A	14.0
Rated torque	Nm	0.15
Rated current	A	3.1
Back-emf constant	V/rpm	0.006
Speed constant	rpm/V	167
Torque constant	Nm/A	0.057
Terminal resistance	Ω	1.7

Table:3 Specification sheet of D.C Motor

The DC motor, an electrical machine that converts electrical energy into mechanical energy, functions based on the interaction of electric currents and magnetic fields that create magnetic fields. The application of DC motors spans a broad spectrum, from small toys and domestic appliances to industrial-grade equipment capable of withstanding heavy-duty use.

The rotor and the stator are the two fundamental components of a DC motor. The rotor, the motor's moving part, usually consists of a shaft, a commutator, and a set of coils, while the stator, the stationary portion of the motor, includes a sequence of magnets arranged around the rotor.

By passing an electric current through the rotor's coils, a magnetic field is produced that interacts with the magnetic field of the stator, in-turn resulting in the rotatory action of the rotor. The motor's direction and speed can be controlled by regulating the direction and magnitude of the electric current.

DC motors are known for their straightforward design, effectiveness, and simplicity of regulation. They are frequently utilized in situations where substantial force is needed at low velocities, including electric vehicles, robots, and conveyor systems. DC motors can also be utilized in situations where precise speed control is required, such as in machine tools and printing presses.

V. SOFTWARE COMPONENTS

A. Ubuntu 12.04

Ubuntu 12.04, also known as "Precise Pangolin," was a version of the Ubuntu operating system that was released in April 2012. It was a Long-Term Support (LTS) release, which meant that it received updates and support for a period of five years, making it a popular choice for enterprise and other long-term use cases.

One of the main features of Ubuntu 12.04 was its use of the Unity desktop environment, which was designed to provide a more streamlined and user-friendly experience for desktop users. In addition, the operating system incorporated a variety of frequently-used open-source programs like the LibreOffice productivity suite, the Firefox web browser, and the Thunderbird email client.

In addition to its desktop features, Ubuntu 12.04 also included many server-specific enhancements, including support for the latest versions of many popular server applications, such as MySQL and Apache. It also included the Juju orchestration tool, which allowed administrators to deploy and manage large-scale server applications with ease.

B. Python

Python is a high-level, general-purpose programming language that emphasizes code readability and ease of use. It features a simple syntax and supports various programming paradigms, such as procedural, object-oriented, and functional programming. Python is an interpreted language, meaning that the code is executed line by line, which makes it ideal for quick prototyping and development. It has a vast and active community that produces a multitude of libraries and modules, making it suitable for various applications, including web development, scientific computing, data analysis, and artificial intelligence.

Python is popular for its simplicity and readability, making it an ideal language for both beginners and experienced developers. Its clean and concise syntax places emphasis on code readability, which reduces the cost of program maintenance. Additionally, Python has a large and active community of developers who contribute to the development of libraries, tools, and frameworks that make it even easier to use.

Due to its uniqueness of being an interpreted-language and portability, python programming can run on many different platforms, which include Windows and Mac, and other operating systems such as Linux, and it even supports on various embedded computer systems and hand-held devices. Python also promotes productivity, and efficiency in various software development environments.

C. OpenCV

It is a widely-used open-source library that provides developers with tools and algorithms for programs that perform real-time analysis on visual-data. Initially, it was developed by Intel, however, now maintained by the OpenCV community.

OpenCV includes a wide range of image processing and computer vision algorithms, such as object detection, feature extraction, and motion tracking. This unique package or extension offers support for various programming languages such as C++, Python, and Java. Furthermore, it is designed to work seamlessly on multiple operating systems such as Windows, Mac, and Linux.

One of the main features of OpenCV is its ability to work with real-time video streams. It can capture video from a webcam or other video source and process it in real-time to detect and track objects, recognize faces, and perform other computer vision tasks. This makes it a powerful tool for applications such as security monitoring, robotics, and augmented reality.

OpenCV also provides a set of machine learning algorithms that can be used for classification, regression, and clustering tasks. These algorithms can be trained on labelled data sets to execute various tasks, for example object recognition, facial expression recognition, and gesture recognition.

D. Geany

Geany is a lightweight and fast cross-platform Integrated Development Environment (IDE) that is designed for programmers who need a simple and efficient tool to develop software. Since its initial release in 2005, this programming tool has gained popularity among developers who value a coding environment that is both straightforward and flexible.

Geany is known for its user-friendly design and straightforward interface, making it a popular choice among users seeking a simple and intuitive programming tool. It is designed to provide a clean and intuitive interface that allows developers to focus on writing code without being distracted by unnecessary features or cluttered menus. In addition to its user-friendly interface, Geany boasts an array of useful features including syntax highlighting, code folding, and auto-completion, which can significantly streamline the coding process and enhance developers' productivity.

Geany offers extensive customization features that enable developers to adjust the programming environment according to their unique preferences. This tool supports several programming languages, such as C, C++, Java, Python, and PHP, and comes equipped with numerous plugins and add-ons that enhance its overall functionality.

In addition to its features for coding, Geany also includes a built-in terminal emulator, which allows developers to execute commands and run scripts directly from the IDE. It also supports version control systems such as Git, which makes it easy to manage and track changes to code.

E. Xming

Xming is a popular X Window System server that allows users to run graphical applications on remote machines. It was first released in 2000 and has since become a widely used tool for remote computing and network administration.

One of the main features of Xming is its compatibility with many different operating systems, including Windows and Unix-based systems. It provides a simple and efficient way to run X Window applications on a remote machine, without the need for a full desktop environment.

Xming also includes many features that make it a powerful tool for network administration, such as support for SSH and X11 forwarding. This allows users to securely connect to remote machines and run graphical applications over a network connection.

In addition to its features for remote computing, Xming also provides many customization options, such as support for different X Window managers and themes. It also includes a range of plugins and add-ons that extend its functionality even further.

F. PuTTY

PuTTY is a popular open-source network tool that provides users with a simple and secure way to connect to remote machines using various protocols. It was originally released in 1999 and has since become one of the most widely used SSH clients for Windows.

One of the main features of PuTTY is its support for various network protocols, including SSH, Telnet, and Rlogin. With its straight-forward and intuitive interface, this tool enables users to connect to remote machines seamlessly, without requiring any specialized technical skills or knowledge.

PuTTY also includes many features that make it a powerful tool for network administration, such as support for key authentication and encryption. This allows users to securely connect to remote machines over a network connection.

In addition to its features for remote computing, PuTTY also includes many customization options, such as support for different terminal emulations and fonts. It also includes a range of plugins and add-ons that extend its functionality even further.

VI. HARDWARE DEBUGGING

To meet the criteria of cost-effectiveness and performance, the research team chose Raspberry Pi as the arm processor board for their project. They used Arduino-enabled DC motors for robot navigation and directly interfaced the motors to Raspberry Pi to simplify the circuitry and avoid range restrictions. To enable semi-autonomous functionality, the team connected a Raspberry Pi to a Wi-Fi dongle and accessed it remotely via SSH using the PuTTY application. A high-quality webcam was used to capture gesture movements, and the DC motors were powered by a 12V battery capable of 200 rpm.

VII. SOFTWARE FLOW-DIAGRAM

For better understanding of the work flow of our project, here is a simplified systematic diagram of our project in the form of a flow chart.
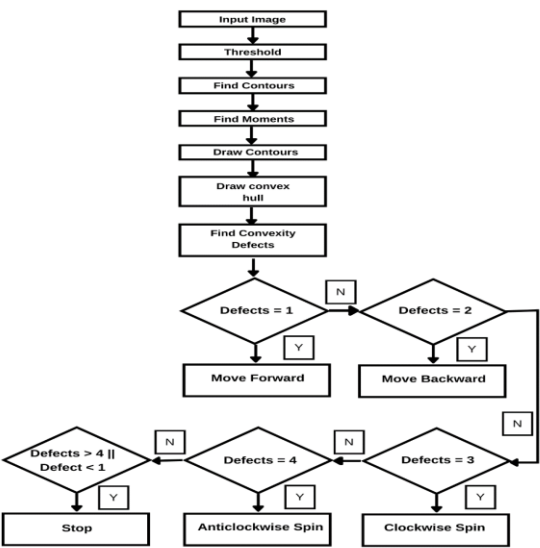

Figure:2 Flowchart

VIII. RESULTS AND DISCUSSION

The first set of images, as shown in the fig. consists of input images that are captured by the webcam. As we know through the concept of lists, in python, any data type can have its unique value. In the same way, each of the gesture images captured, can be set as a directional variable for the project.

Figure 3: Input Images

The images captured are then passed through the analyser, where it verifies the image through comparing it to the images present in the database, and finding the match of the action that the gesture represented should perform.
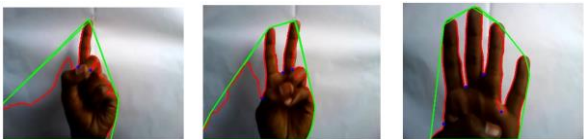

Figure 4: Output Images

And finally, the model moves around the environment as per the data received by the individual. It was also noted that, on increasing the amount of training and validation sessions, it increases the efficiency of the project.

IX. CONCLUSION

The researchers aimed to develop an adaptive and rehabilitative solution for wheelchair users that could be controlled using hand gestures and wireless routing. Their effort was successful, resulting in the creation of a robot that could be guided by hand gestures and integrated with a wheelchair, providing much-needed assistance to individuals with disabilities and enabling them to live independently. This technology relied on Raspberry Pi's compactness and reliability, as well as its use of image processing, which eliminated the need for a laptop. Frames were used as inputs to direct the robot's movements. This breakthrough could be a significant contribution to adaptive technology for wheelchairs, offering a cost-effective alternative to existing remote and voice-controlled devices.

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